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Vol. XXV, pp. 113–142, plate XXXIII

Issued by the Discovery Committee, Colonial Office, London
on behalf of the Government of the Dependencies of the Falkland Islands

THE HABITS OF FIN WHALES

by

E. R. Gunther

CAMBRIDGE
AT THE UNIVERSITY PRESS
1949

Price four shillings

PUBLISHED BY
THE SYNDICS OF THE CAMBRIDGE UNIVERSITY PRESS
London Office: Bentley House, N.W. 1
American Branch: New York
Agents for Canada, India, and Pakistan: Macmillan

Printed in Great Britain at the University Press, Cambridge
(Brooke Crutchley, University Printer)

[*Discovery Reports. Vol. XXV, pp.* 113–142, *Plate XXXIII, July* 1949.]

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THE HABITS OF FIN WHALES[1]

By E. R. Gunther

(Plate XXXIII; Text-figs. 1–7)

INTRODUCTION

In the present paper various observations of whales, as they have been seen at sea, have been put together in the hope that they will contribute to a broader understanding of the relations of the living whale to its environment. The observations were made from a modern whale catcher, the *Skua*, while engaged upon whale-marking work[2] in the neighbourhood of South Georgia during the two months 11 December 1936 to 9 February 1937. The author had a stop-watch but no cinematograph camera, and in consequence many of the conclusions made in the following pages are open to amendment.

The difficulties of making observations on living whales are many. They show themselves above water for only brief periods, and their specialization for life in the water renders direct comparison with the behaviour of land mammals hazardous. Opportunities of watching them at close quarters have usually been restricted to vessels engaged in whaling; on board which life has to be lived to be understood. True (1903), who has used a camera on board a catcher, has remarked '...the difficulty of getting the picture itself is so great that one's faculties are entirely absorbed in the proceeding and there is little opportunity for observing particulars. The pitching and rolling of the steamer in the restless waters is very disconcerting, and not less so the fact that the point at which the whale will appear is uncertain and the length of time it will remain in view very brief.' It is noteworthy that True's photographs were secured in calm weather.

A research ship has certain advantages over the commercial catcher. She is on the whaling grounds for longer periods, and when following a school, the chase does not terminate when one whale has been hit. While the firing of marking guns has a disturbing effect upon whales, the noise is not to be compared with the report of a commercial harpoon gun and probably gives correspondingly less shock. The motion of a catcher is, of course, the same whether she is actually used for catching whales or not. She completes a roll in 4 sec. and this means that the opportunity to fire marks occurs momentarily every 2 sec. when the ship is either at the crest or the trough. Another factor making for great difficulty in the collection of scientific data in the Sub-Antarctic is the incessant spraying of cold water over the gun platform so that on many days it is impossible to use pencil and paper.

The report is divided into three parts and it concerns only the habits of the Fin whale (*Balaenoptera*

[1] This paper was nearly completed by the late Mr Gunther in 1939. His death on active service, however, took place in 1940, and the MS. was not available until after the war. The text and illustrations are printed almost as he left them, except for two passages which seemed to need revision. Thus the first sentence has been written in place of three short opening paragraphs, and on p. 121 the two paragraphs beginning, 'Over all the periods of observation...', and ending, 'breathing intervals of different whales', replace a passage equivalent to rather less than a page of text (together with three text-figures) in which the data on the frequency of blowing were further discussed. It is believed that these two paragraphs summarize the author's line of thought. He could no doubt have adjusted both the original passages by a few amendments, but to revise them now in full might involve a departure from his intentions. Elsewhere in the text only trivial editorial work has been needed. Among the illustrations the author had provisionally chosen nine photographs. Of these the six reproduced in Plate XXXIII are the most suitable for reproduction and seem to meet the author's requirements.—*Ed.*

[2] See Rayner, 1940.

physalus). Part I, as far as permitted by the nature of the observations, is an account of the whales as they have been seen at the surface. Inferences of what goes on below the surface, and comparisons with the observations of earlier authors, are left as far as possible until Parts II and III.

I. APPEARANCE AT THE SURFACE

Opportunities of observing cetacea occur both when they are under water near the surface and when they break surface to blow.[1] They have also been known to break surface without blowing. As, however, they are usually blowing when they are seen, it will be convenient first to consider various ways in which they come up to breathe.

Breaking surface to breathe

The length of time a mature Fin whale shows above water usually varies from 3 to 6 sec. and sometimes lasts for as long as $7\frac{1}{2}$ sec.; calves show for shorter periods of 2–$2\frac{1}{2}$ sec. The time is divisible into two periods: the first a very short period of little more than 1 sec. during which the head emerges and submerges again, and then a period of variable duration, of from 2 to $6\frac{1}{2}$ sec. during which the rest of the body follows. The first period seems to vary comparatively little. The length of time the whale shows above water depends then mainly upon the length of the second period, and this depends very largely on what he is doing.

For simplicity of treatment three examples may be chosen to illustrate the different methods employed in breaking surface. They are discussed in later pages but it may be well here to bear in mind that no one of the methods need be rigidly adhered to.

(i) *Slow.* A whale breaking surface to blow very leisurely, approaches the surface horizontally and swims slowly (Fig. 1*a*). Its upward motion, in a more or less horizontal position, resembles the action of a submarine and can be watched for several seconds before it breaks the surface. The head and back break surface almost simultaneously and the whale blows. At the slowest speed the snout seems mostly to remain beneath the surface. The blowing over, the head is lowered as the dorsal fin emerges, so that for a split second both show above water (Fig. 1*b*; Pl. XXXIII, figs. 1, 2). The whole body then sinks, and the whale, still comparatively horizontal, submerges. This leisurely blowing ($7\frac{1}{2}$ sec.) gives a smaller target than the hurried movement.

(ii) *Medium speed.* Whales may be considered to be breaking surface at medium speed ($5\frac{1}{2}$–$6\frac{1}{2}$ sec.) when, as frequently happens, they approach the surface at an angle of 25–35°; in this action they can also be seen for some moments before emergence and at this angle their attitude bears some resemblance to a tadpole gulping air at the surface of a pond. The tip of the snout is first seen and an appreciable extent (say one-third to one-half or more) of the lower jaw emerges (fig. 1*d*, *e*, and also True, 1903, plate XXIV, fig. 2). In head-on view the white chin and the ventral grooves are plainly visible from the catcher's bows. As soon as the blowhole is free the whale blows; but as it does so the head is dipped. As the head becomes horizontal, the upper jaw and, if visible, the whale-bone plates, are above the surface but the lower jaw is awash. The eye appears to be hidden by the wash which the lower jaw sets up. Further dipping of the head bends the anterior part of the body into an arc and as the whale moves forward the blowhole disappears from view (Fig. 1*f*, *g*; Plate XXXIII, figs. 3, 4). All this has happened in a surprisingly short time and constitutes stage 1.

The tip of the dorsal fin may break surface before the back is wholly out of the water, but the fin and blowhole are seldom visible together (Fig. 1*g*). The whale illustrated in Plate XXXIII, fig. 1, while showing both blowhole, fin and peduncle, appears to be swimming more horizontally and rather

[1] The word 'blow' is used throughout this account for the act of expiration and inspiration. It is synonymous with 'spout' which, however, is open to confusion with the traditional idea of a spouting column of water.

slower than the whale in fig. 2 of the same plate. As a result of further flexure, which can sometimes be seen to be effected by muscles of the back, the mid part of the body travels through the arc set by the head and neck (Fig. 1*h*). As the whale travels forward, the trunk and fin rise out of the water (Fig. 1*i*, and *j*); then, giving place to the caudal peduncle, the trunk begins to sink (Fig. 1*k*, *l*). The general effect after the dipping of the head is that of a wheeling motion of the back out of the sea and into it again. But the fin, having wheeled out of the water, acquires a cam-like action and having reached its zenith, the wheeling motion stops. The outstanding parts now slowly sink, travelling forwards slowly. The caudal peduncle submerges, together with the posterior part of the trunk, and the fin is generally the last to disappear from view (Fig. 1*m*). The fin and caudal peduncle often disappear simultaneously, but the peduncle seldom by itself and then only when the angle of diving is unusually steep. A whale blowing in this manner offers the best target not only because the movement is comparatively slow but also because the head, trunk and caudal peduncle are well elevated.

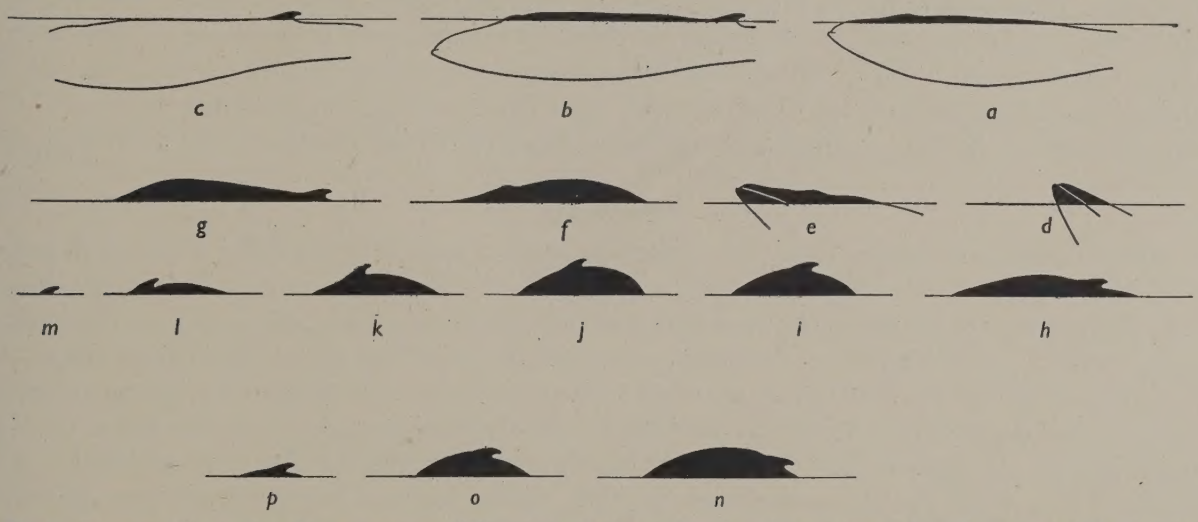

Fig. 1. Diagrams illustrating the appearances of Fin whales at the surface; based on photographs and notes, and on a drawing by J. F. G. Wheeler (Mackintosh and Wheeler, 1929). *a–c*, whale blowing leisurely; *d–m*, at medium speed; *n–p*, fast.

The whale may go through these motions faster or slower, a period of $4\frac{1}{2}$–6 sec. elapsing between the act of blowing and the disappearance of the dorsal fin ($5\frac{1}{2}$–7 sec. overall). A whale in a hurry blows off air before reaching the surface and a dome of silvery bubbles momentarily appears over the back of the neck. According to the speed of blowing depends the splash. A whale shooting its head out of the water fast, sometimes lets it down fast and the surface splash, accompanied by waves, spreads several yards to right and left. Disappearance of the fin and caudal peduncle, however, is unattended by splash.

Here it may be convenient to refer to the so-called 'oily patch' (or 'slick', True, 1903) left by the whales at the surface after their disappearance. The smoothness of these patches resembles closely the wake of a steamship, and the welling which is observed in them is doubtless produced by the tail flukes and affords useful evidence of their action.

(iii) *Fast.* When blowing is brisk, the whale appears and disappears so quickly (3–$3\frac{1}{2}$ sec.) that the details of its movement are hard to pick up and whales breaking surface in this way have not, during this whale-marking commission, been spotted beneath the surface beforehand. The whale appears suddenly and simultaneously blows. The tip of the snout is again the first part to emerge and the head shows above water for little more than a second as before. The movements are probably similar to those undergone in breaking surface at medium speed, but carried out with greater impetus. The body

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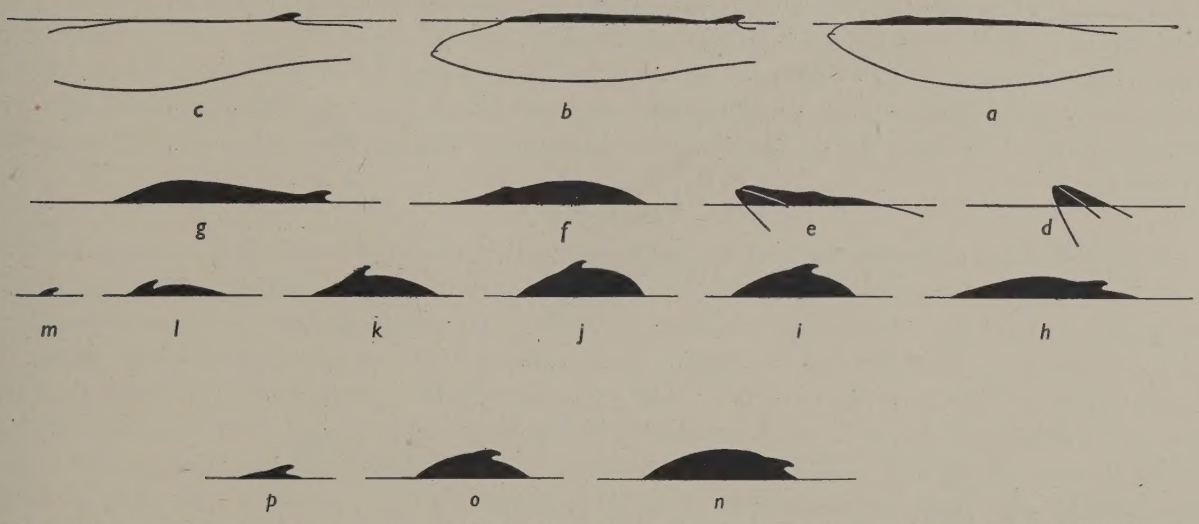

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is thrown into an arc of small radius and moves high out of the water so that an unusual depth of flank is momentarily visible (Fig. 1*n*; Plate XXXIII, fig. 5). The amount of wheeling motion appears to be curtailed and the downward sinking comes on sooner, sometimes with lateral splashing. The fin and caudal peduncle are again the last to disappear (Fig. 1*o*, *p*).

Breaking surface without breathing

On various occasions whales have been seen to break surface without blowing. On 22 December, the dorsal fins of two were seen above the water. The whales were leisurely, and on approach of the ship the fins submerged slowly. On 11 January, while whales were feeding upon krill close to the surface, tail flukes (either right or left) and flippers often broke surface, and the former waved in the air as though in execution of swimming movements. The significance of this will be referred to in the notes upon feeding (pp. 124 and 133). On 31 January a whale beneath the surface, a point or two off the course, made straight for the ship's stem and only averted collision by a sudden dive beneath the keel when a yard or two away. As he did so, the dorsal fin and the caudal peduncle were momentarily thrust out of the water. On 7 February, two other whales broke surface in much the same way. One showed the caudal penduncle as it dived; the other seemed to be on the point of blowing but apparently changed its mind, the head and neck broke surface in the act of dipping, but most of the back remained covered.

Swimming

A view of whales swimming close to the surface is usually distorted by waves and wavelets, and the movements are hard to determine. As in their other activities, the larger rorquals look stately when they swim because of a majestic ease of motion, even when they are keeping abreast of a ship steaming at 10–12 knots. Seen from above, the flippers slope backwards but are spread out from the sides.

An idea of the rhythm of the tail flukes could be formed if it were possible to measure the distance between the 'oily patches'. It will be remembered that these are produced from the action of the flukes through the upward gush of water. At speeds of 10–12 knots, these patches appeared to be separated by 5–10 yards and as many as six or ten in series sometimes became visible when a whale was near the surface. According to these data, which are very rough, the flukes beat once every 1 or 2 sec. When a fluke is waved from side to side above the surface of the water, its rhythm appears rather faster but was not timed.

No whale was seen to swim twice as fast as the ship at full speed. The *Skua* was not able to steam faster than 12 knots, but the whales seemed, on occasion, to spurt half as fast again, and this would bring their speed for short distances up to 16–18 knots.

Frequency of blowing

Data on respiratory rhythm have been collected by timing the blowing of whales with a stop-watch. As often as opportunity offered, the observations were taken in unbroken series but often they had to be curtailed and then they consisted of no more than one or a few breathing intervals. Thus the observations may be looked upon as of two kinds, A and B. The first (A) at a distance from the ship spread over longer periods and the second (B) of supplementary observations on individual whales nearer the ship.

In the serial observations A, the stop-watch was started at the first sign of blowing and stopped at the next, and in order to secure continuity of record, was immediately re-set and restarted. While, therefore, the first observation in each series represents the time from blow to blow, the succeeding observations represent the same less the time taken to read the watch which was about 2·15 sec., and the data as given in Table 3 (p. 137) have been suitably adjusted.

The data fall short of what is required in many ways. In addition to the difficulties mentioned earlier in the paper, the stop-watch was out of action for some weeks, and the following circumstances have also to be considered before the data are subjected to scrutiny. Serial observations were seldom

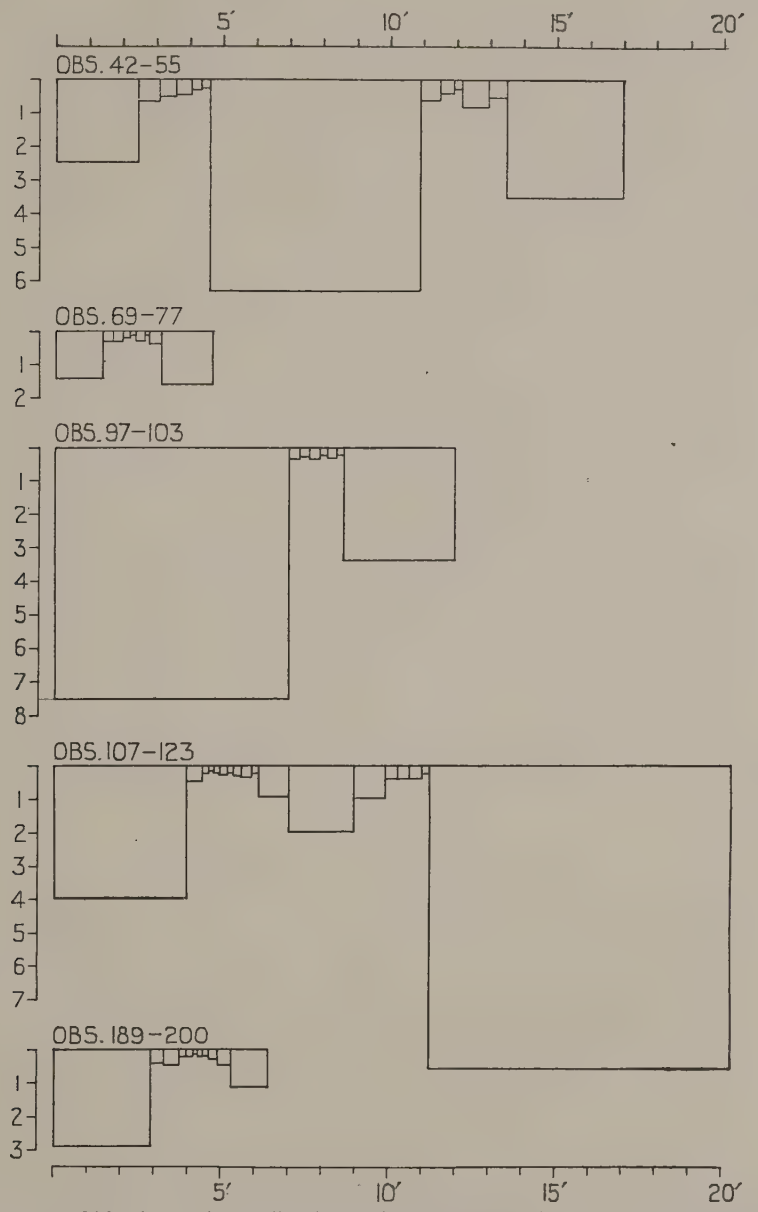

Fig. 2. Sequence of blowing and sounding intervals in minutes. The intervals are proportional to the minimum length of breath.

possible for periods longer than 20 min. A whale that might be sighted by the ship at a distance of 4–5 miles would be reached in 25–35 min., but might be disturbed considerably earlier. Evidence of such disturbance will shortly be examined. After this, observations were interrupted by marking work. Thus the observations were made as and when the marking programme permitted.

The tendency of Fin whales to swim in pairs or in schools, means that few, if any, of those appearing at a distance to be alone, are without doubt known to be unaccompanied: indeed, the data listed in

the Tables give evidence that more than one whale was under observation in each of the series of timing records made. This is most easily seen in the maximum numbers of whales blowing simultaneously, a datum which indicates with a high degree of probability the number of whales in the school.

Kemp and Bennett (1932, p. 174) have pointed out that 'If, as often happens, several whales are in company, they will generally rise to the surface and blow simultaneously. When whales are not plentiful it is possible to be reasonably certain that the same school is being kept under observation; but when they are abundant the difficulties are greatly increased.'

If the tendency to blow together could be relied upon, and the whales could be timed as a school, interpretation of these data (*A*) would be straightforward. Unfortunately, however, the appearances of the whales at the surface show a good deal of overlap and though the school often does blow together, irregularity is frequent. In view of the likelihood of confusing the blowing of one whale with that of another, the results would appear to lend themselves to almost any interpretation. But analysis shows that this is not so. The data show certain features which cannot be regarded as fortuitous: and some of these features are confirmed by the supplementary observations (B). These latter consist of isolated observations of whales close to the ship and they are important because they are believed, with a fair degree of certainty, to represent the behaviour of individual whales. The two classes of observations will therefore be considered together.

In series B, whales were commonly observed to blow at intervals of about 24–28 sec. about five or six times in succession, whereupon they sounded for a longer period. On 7 February, for example, a whale blew five times at more or less regular intervals in the course of 100 sec. and then disappeared. On 19 December, blowing went on at short intervals for 115 sec. in one instance and 140 sec. in another before the animal sounded. On occasion, when larger schools have been watched, the school has risen more often, but not every whale has come to the surface at every blowing.

Parallel instances of such rhythm in series A occur among the tabulated data and selected examples are shown in Table 1. They are illustrated in Fig. 2.

Table 1. *Comparing the lengths of the periods of sounding (I and II) with the interim period during which blowing intervals were noted*

Date	Serial no. of observation	Duration of sounding I	Interim period		Duration of sounding II	Estimated no. of whales	No. of blows observed
			Duration	No. of blowing intervals			
		min. sec.	sec.		min. sec.		
14. xii. 36	42–49	2 28	125	6	6 23	2	8
	49–55	6 23	155	6	3 27	2	7
	69–77	1 27	101	8	1 38	2	10?
22. xii. 36	97–103	7 30	100	7	3 18	2	7?
	107–117	4 27	130	10	2 52	2	10?
	117–123	2 52	132	6	9 02	2	8?
27. xii. 36	189–200	2 52	144	10	1 17	3	20?

The absence of this particular rhythm (of blowing and sounding) among others of the data listed in Table 3 may be due to the fact that some or all of the whales were behaving differently. Evidence of different rhythm is given by the whales timed on 27 December. They were first observed more than a mile off; they were approached, passed, and finally left on the starboard quarter. The observations nos. 189–200, while the whales were far off, have the rhythm illustrated in Fig. 2, but the subsequent observations, nos. 201–261, show no trace of it.

A similar though more remarkable change in the respiratory rhythm was observed (series B) in a school of six or seven whales on 3 February. At 11.15 hr. whales were sounding for long periods (4–6 min.) and between whiles were blowing a few times at short intervals in apparent unison. After many and usually fruitless attempts had been made to approach them, at 12.15 hr. they suddenly altered their behaviour in a stampede towards the south. They no longer remained below for long periods and as we slowly overhauled them, hopes of marking rose. At 13.00 hr., however, their behaviour again changed. Their complacence returned and they sounded for lengthy periods.

The rhythm demonstrated in Table 1 confirms the belief that individual behaviour may be studied in collective behaviour, for their sounding together would be unlikely if the whales' actions were unrelated. It may be helpful to compare the lengths of time the whales remained below water when sounding (interval of sounding) and the interim periods during which breaths were taken (i.e. the total of the periods occupied by successive intervals of blowing). The probability of being able to distinguish an interval of sounding from an interval of blowing is likewise important.

Two records of the latter already cited (B), were 115 and 140 sec. and they compared with sounding periods of 3 min. 8 sec., 3 min. 35 sec., 4 min. 10 sec. and 4 min. 23 sec. These figures imply that sometimes at least the sounding periods exceed the length of the interim periods.

For the purposes of comparison, an arbitrary length of time may be chosen to distinguish between the 'interval of sounding' and the 'interval of blowing'. On the basis of the data collected during the observations of 19 December, according to which the whales blew several times during the course of 140 sec., an arbitrary limit of 1 min. is liberal as an allowance for the single 'blowing interval' and any longer period of submergence may be regarded as a 'sounding interval'. When classified into intervals of less than a minute and of more than a minute, and summed, the data (A) in Table 3 give the following ratio:

Interval of blowing:	Interval of sounding::	64 min.:	103 min.
(<1 min.)	(>1 min.)	(38%)	(62%)

Over all the periods of observation, therefore, whales were 'sounding', according to this empirical definition, for 62% of the time. The rhythm demonstrated in Table I suggests that, as often as not, the respiratory needs of the animals were similar; and although they did not always blow synchronously, they chose the same periods to visit the surface and the same periods to sound. It follows that a pair or school of whales may be expected to act in unison, in this sense, for at least 62% of the time (or more if the normal 'blowing interval' is less than 1 min.). The timing data are therefore shown not to be vitiated by whales blowing out of time.

It became of interest to know whether the shorter and longer intervals were physiologically distinct or whether they are merely length variants of the same process. If the latter we might expect the longer and shorter intervals to merge and the intervals of medium length to be in the majority. The frequencies of the observed intervals are given in Table 2, showing the greatest frequency among the short intervals and a diminution with increasing length of interval. The figures suggest no obvious discontinuity between the shorter and longer breaths but that the intervals of blowing merge imperceptibly into intervals of sounding. If a distinction can be drawn between the two, the normal limit of the former is likely to be between 40 and 50 sec. A curve made up of eight-second groupings of the frequencies of the intervals of breathing is given in Fig. 3. The peak which shows at 50–54 sec. suggests that this is a frequent and well-defined interval. Intervals of 24–28 sec. were frequently found in the isolated observations (B). An interval of 18 sec. may represent a true interval of blowing, but the intervals of shorter length almost certainly do not, for the manœuvre of breaking surface alone takes 4–7 sec. The shorter intervals are probably brought about by the overlapping of the breathing intervals of different whales.

Table 2. *Frequency distribution of intervals of blowing and sounding*

Interval (sec.)	Total frequency (2 sec.)	Frequency of 4 sec. groups					8 sec. groups frequency	2 min. groups frequency
		(i)	(ii)	(iii)	(iv)	Total		
1–2	—	—	—	—	—	—	15	
3–4	—							
5–6	11	—	6	4	5	15		
7–8	14							
9–10	25	3	29	12	6	50	81	
11–12	25							
13–14	21	3	22	3	3	31		
15–16	10							
17–18	24	8	26	6	1	41	66	
19–20	17							
21–22	18	6	13	2	4	25		
23–24	7							
25–26	13	11	10	2	4	27	33	
27–28	14							
29–30	5	4	1	—	1	6		
31–32	1							
33–34	5	3	3	—	2	8	13	
35–36	3							
37–38	2	3	1	—	1	5		
39–40	3							
41–42	—	1	—	—	—	1	2	
43–44	1							
45–46	—	1	—	—	—	1		
47–48	1							
49–50	1	3	1	—	—	4	9	
51–52	3							
53–54	3	—	3	1	1	5		
55–56	2							
57–58	1	—	1	—	—	1	1	
59–60	—							
(min.)								
0	220							227
1	7							
2	7							11
3	4							
4	2							4
5	2							
6	4							5
7	1							
8	—							1
9	1							

Note. (i) Frequency of series 1 and 3 (vide Table 3).
(ii) Frequency of series 2, 4, 5, 7, 8, 10, 13 and 15.
(iii) Frequency of series 11.
(iv) Frequency of series 6, 12, 14 and observations 78–79.

The response of whales to marking

Whales are disturbed by the sound of the ship, by the report of whale-marking guns and by the impact of the marks. At the sound of the ship they usually moved off gently, but at the report of a marking gun, or when hit with a mark they sometimes bolted to a safe distance and then slowed down.

The most timid took flight on approach of the ship: they swam off in a set direction or erratically, but keeping well out of range of the guns. A ship of 10–12 knots has no hope of overtaking these whales and they were usually abandoned by us after an hour's chase.

The less timid took flight on approach of the ship but allowed themselves to be overtaken after pursuit.

On 3 January when the whales were inclined to be on the timid side, schools of two to four allowed the ship to come within range after perhaps 10–30 min. chasing, but went out of reach immediately one of their number had been hit. On the same day a gun was accidentally discharged at a distance of 100–200 yards behind a school of 9–10 and the whales became unapproachable.

At other times a school may allow the ship at close quarters, though after every round of hitting the whales take temporary flight. Some whales grow less approachable, others more so under this treatment.

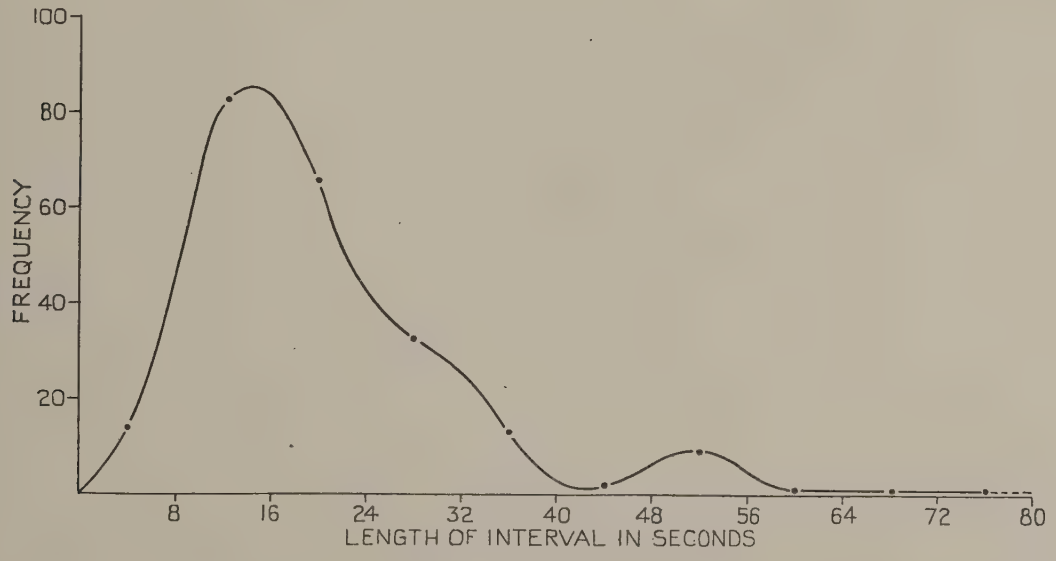

Fig. 3. Curve illustrating the frequency distribution of blowing intervals, with data lumped into 8 sec. groups.

In contrast to the occasions when whales fled from the whale-marking vessel, are the times when they took no notice of her and when they even seemed attracted. These occasions were few and as the circumstances suggest that the whales were in the act of, or had been, feeding, they will be considered later.

Another response, especially characteristic of the larger schools, is a tendency to split up into smaller groups. On 29 December, for example, a school of probably fifty split into halves. The half pursued soon split again so that no more than a dozen whales or so could be chased as a body. Later, these in turn dispersed into smaller schools of threes, fours, fives or sixes. Such splitting was frequent.

Whales very often seemed to wince on being hit by a mark: indicated by a twitching of the dorsal fin (28 December), and sometimes by a quivering of the muscles of the flank as in a horse (21 January), or by a kick with one of the tail flukes (11 January). The fluke would flick out of the water, beating about with the flourish of an irritated animal, and send up an awesome splash, sometimes wetting the ship's forecastle.

Whales not hit have also been seen to kick with a fluke at the report of a gun, though the mark that was fired was aimed at another whale and had missed it (7 February). And whales that have come towards the surface with the evident intention of blowing have, at the report of a gun, dived again.

This reaction suggests a change of mind and it has usually happened well in advance of the need to break surface; but sometimes it has happened when emergence was inevitable, as two or three times when the caudal peduncle, and once the neck region, was thrust out of the water in the act of diving (31 January and 7 February, see p. 128).

Feeding

On 11 January, whales in the act of feeding came under direct observation. A heavy concentration estimated to number 100–200 whales was centred over a patch of whale food in an area of about 4–5 square miles.

The krill (*Euphausia superba*) could be seen in a layer no more than 3 m. below the surface, and in places it affected the colour of the sea. An easterly gale the previous day had left a very heavy swell, but the wind had since moderated and waves were no longer breaking. The sky was grey and the bad visibility was reduced from time to time by patches of mist. The sea was grey too, but in places the krill imparted to it a barely noticeable tinge of ochre. In one place where the krill was unusually thick and might have been closer to the surface, a patch of half an acre or so had a brick-red tinge. The krill was irregularly spread over the whole region with large gaps between the swarms; some measured a few feet across and had an indefinite contour like that of a gorse bush, and others extended in long wavy bands from one to several feet or even metres in width. The krill did not seem as dense as patches of it often are, and it looked as though it had been broken up by the recent gale and had been depleted by the depradations of the whales.

The whales were banded together in small schools of from two to five or six or more; but the schools were probably mixing. The animals were blowing leisurely, and sounding for short periods. In the early part of the day and late in the afternoon they showed a disposition to run away from the ship; but in the middle of the morning, when they seemed to be feeding most actively, they took little heed of us and marking was comparatively easy.

The most conspicuous feature of their feeding was the tendency to swim on one side.[1] From afar, the white ventral surface shone beneath the water so that its blueness was momentarily thrown up. There would appear to be no need to look for any other explanation of this than that it is a method of turning sharply to one side (see p. 131). Whales sometimes turned out of a normal act of blowing on to their side before submerging and sometimes turned while under water; if close to the surface, flipper or fluke broke surface and waved in the air.

A point to be emphasized was the supreme indifference with which the whales accepted the marking and the presence of the marking vessel when actively feeding. They blew leisurely, sometimes swimming towards us, beneath us and by our side, and they seemed to be preoccupied with the question of their meal.

The salient facts in these observations, for purposes of future comparison, are as follows:

(i) The whales were feeding.
(ii) They were close to the surface.
(iii) They were concentrated together.
(iv) The schools were of varying size.
(v) They were blowing leisurely and at short intervals.
(vi) Their unconcern for the ship gave an appearance of preoccupation.

A rather similar state of things was observed north-west of the South Sandwich Islands on 22 January. During the morning the ship had been pursuing whales, but marking with only partial success, for the schools were unapproachable and one after another had led the ship a run of 30–40

[1] I am informed by Mr G. W. Rayner that Norwegian whalers have the word 'boltering' to describe this habit.

miles. In one of these chases at 13.00 hr. the ship came upon an area of about a square mile where ten to thirty whales were blowing leisurely. No krill was to be seen but a concourse of blackfish and dolphins crossed the area during our work. The whales were swimming close under the surface, came within a stone's throw of the ship and allowed themselves to be marked; they seemed to be crossing and recrossing the area. When the ship passed on to another region, the whales there showed the timidity of those we had seen earlier in the day.

Although no krill was visible, the presence of dolphins and blackfish presumes an abundant food supply: and though there is no direct evidence that the whales were feeding, their behaviour bore a resemblance to that of the whales met with on 11 January and contrasts with that of others in the immediate neighbourhood but outside this concentration, which were seen at almost the same time and under the same weather conditions.

The salient points may be thus tabulated:

(i) The presence of food is inferred from the concourse of the smaller as well as of the larger cetacea.
(ii) The whales were close to the surface.
(iii) The schools were of varying size.
(iv) They were blowing leisurely and at short intervals.
(v) The whales were quite unconcerned.

On 8 January around the Shag Rocks, in the middle of the day from 10.00 to 16.00 hr., the whales showed an unconcern for the ship which was in marked contrast with their usual behaviour. Chasing was begun at dawn in fine calm weather. Whales were plentiful and schools, varying in size from three or four to ten or twenty individuals, were discerned on various quarters of the horizon. Marking efforts were not unsuccessful, for as many as three or four hits in a school of six or seven were sometimes recorded before the school in question split and those whales took to prolonged flight. The whales were not sounding for more than 2–3 min. and, until disturbed, they were blowing leisurely.

Between eight and ten o'clock the attitude of the whales changed: they became scarcer and were more difficult of approach. Marking all but came to an end. The schools seemed to have scattered and apparently regardless of the operations of the ship, the whales seemed to have split up into twos and threes. They were remaining down for long periods (5–7 min.), and when they came up they were usually up to half a mile from the ship and blowing, if unhurriedly, also a trifle stertorously. The ship takes about 3 min. to steam half a mile; but however leisurely the whales were blowing—and they blew at least five or six times—3 min. was ample for their purpose. The ship was invariably on the scene too late and the whales sounded just before a shot was possible.

The whales paid no particular attention to the ship; when blowing they swam on a straight course and they did not deviate as we approached them. When they next appeared, they again had ample time to blow five times before the ship could reach them; as it did so they sounded.

In the evening, between 16.00 and 18.00 hr., whales again tended to coalesce and again allowed themselves to be pursued, and an average of one to two hits in a school of three to five whales was scored. The whales remained below for shorter periods (2–4 min.), and when on the run sounding lasted for still shorter periods (1–2 min.).

Later still, the whales had gathered into even larger schools. At 20.00 hr., a school of some twenty had been formed. They were continually breaking surface and blowing, and appeared to be disporting themselves. At first marking was easy, the whales swimming round without heed. At the sound of the guns they began to make off, but those we chased played around the ship as do dolphins; they leapt high though not completely out of the water, appeared now on the starboard bow, now on the

port; then they would streak ahead jumping high, sometimes in pairs, sometimes in threes and sometimes in unison, and then came closer to the ship again. Soon they split again, and the fewer they were the more wary they became and the harder to mark.

This one day was particularly memorable as giving us whales in three distinct moods: in early morning and late afternoon the schools of medium size which allowed pursuit and approach; before and after noon, the very small schools that were indifferent; in the late evening, the sportive whales in a large gathering. One or other of the same moods was recognized on other occasions also.

If a disposition to be preoccupied indicates that whales are feeding, as the observations on 11 and 22 January have been interpreted, then their aloof manner at noon on 8 January points to the same conclusion. Here, their behaviour had the following characteristics:

(i) The whales were widely scattered.
(ii) The schools were very small.
(iii) They were blowing leisurely at long intervals.
(iv) The whales were preoccupied.
(v) The hour was round about noon.

The most noticeable way in which behaviour on 8 January differed from that on 11 and 22 January, was the greater depth to which the whales may be inferred from (iii) to have been sounding, and the very small size of the schools. The former is thus a sign that the krill were at some considerable depth while the smallness of the school seems in some way connected.

The gathering into larger schools towards evening, the high spirits and the attention to the ship, go to indicate that the work of the day was over. We came to regard the evening as a time when whales were likely to be more markable; and in the opinion of the writer the change of attitude affords circumstantial evidence that earlier in the day, good feeding had been found at considerable depths.

Through the night, the whales may equally have been feeding or resting. What they were doing at dawn did not become apparent either. In the early morning, the schools were usually bigger and less restive, and the whales still easier to mark than later in the day.

Off South Georgia on 16 January, three whales provided, in another locality, an excellent example of the aloofness with which feeding in deep water has come to be identified. For a good hour, the ship had been hanging round the first of these whales and the prospect of marking it seemed hopeless—the animal sounded for long periods and always rose out of reach. At last at 17.10 hr. the miracle happened: the whale reappeared close to us and swam on a course which must cross our path. In many circumstances it would have turned away, but in holding its course and in diving to avoid collision it showed itself to be preoccupied, and in the light of other observations, the conclusion is irresistible that it was busy feeding.

A second example was a pair of whales met with shortly before sunset which in turn detained the ship for over an hour. When at last at 20.00 hr. by a stroke of genius, the captain manœuvred the ship into their line of advance, the whales, instead of fleeing, continued in their courses and the pair was marked in two consecutive shots (mark nos. 7006 and 7011).

Gambols and eccentricities of behaviour

Beyond suggesting that whales take part in pursuits usually termed 'play', the following note is inconclusive. That whales have shown excitement after a day's feeding has been mentioned. A gathering of them in much the same mood was met close to the surface at 13.00 hr. on 29 December. They were estimated to number about fifty and were blowing in succession with a continuity suggestive of a rocket display. The school did not seem to be feeding at the moment of our arrival, for almost

immediately it split and the whales we pursued split up again, allowing themselves to be chased late into the afternoon. Some seventeen hits only were scored. Had the animals been feeding, they would not, presumably, have allowed themselves to be chased 20 miles from the site of their food and might have been expected to show a certain indifference to the ship. The fact that they were not more approachable probably argues that they were not surfeited. Their gathering in such numbers at noon is an unexplained incident.

A similar concentration of about fifty whales was also met at 09.50 hr. on 27 December. Again, their numbers split immediately on our arrival. The visibility was not good and at 13.00 hr., after nineteen hits had been recorded, the original concentration was lost in mist.

Sometimes whales indulge in superfluous splashing when in flight. On 13 or 14 December, a school of maybe ten whales were chased at 11–12 knots. One or more of the leaders, whenever coming up to blow, slapped the surface with its head, raising sheets of spray for yards to right and left. Similar splashing has been noticed on other occasions, conspicuously in a Fin whale chased by the *William Scoresby* on 24–25 January 1931: this whale was not sounding, however, and was running away at an estimated speed of more than 12 knots.

On 21 January a single Blue whale was consorting with four to five Fin whales (mark no. 7078). The school fled, but periodically allowed the ship to overtake it and seemed to show some interest in the ship; in the course of an hour or two several were marked. The Blue whale detached itself from the school and swam within a few feet of us. It took no notice of the firing, leaping high though not clear of the water, now to the right and now to the left of the bows, and often within arm's length. The antics could not have been watched at closer quarters, but the fading light and the quickness of jumping made a detailed view of the movements impossible.

Whales have not infrequently flicked a tail fluke out of the water in the final act of diving—a mannerism very similar to but apparently distinct from the kicking movement after being hit, for it has been observed far from the ship. Certain whales were given to it more than others; some seemed prone to lift the right fluke, others the left.

Another eccentricity was shown by one whale on 22 December and by two whales on 7 January which blew without showing the dorsal fin.

Sei whales were always very difficult of approach. They took more erratic courses than Fin whales and kept well out of range; when they reappeared after sounding they were usually far away and moving in any but the direction in which the ship was heading. They were met with on few occasions.

II. MOVEMENTS BENEATH THE SURFACE

Various details in the movement of the whale as it breaks surface throw light upon the motions of the body beneath the water, though the mechanical and hydro-dynamical principles underlying these actions must at present remain undetermined.

Breaking surface

Comparison of the slow, medium and fast methods of breaking surface suggest that the three following relations are often found:

(i) The degree of curvature of the body varies inversely with the period spent above water.
(ii) The depth of body showing above water also varies inversely with the period spent above water.
(iii) The period spent above water seems to vary inversely with the swimming velocity.

From these observations it may be argued that whales without momentum have some difficulty in leaving the surface, and it may be noted that the respiratory process occupies but a small fraction of

the total period spent above water (p. 116); the rest of the time seems to be devoted to getting below again, which usually takes much longer than coming up.

A whale at the surface probably has two primary mechanical disadvantages to contend with, the surface drag and the insufficient purchase which a thin surface layer affords to the action of the flukes.

A whale at rest, or swimming slowly at the surface, in a more or less horizontal posture (Fig. 4), is probably at this disadvantage, and submergence by means of the forward motion usually observed probably means that submergence is most easily effected gradually.

The impetus acquired by whales blowing more quickly would thus appear to have a purpose in preventing a situation from arising which would be mechanically weak and would retard submergence. The movements of such whales beneath the surface appear to be as follows.

The appearance of the head and neck when the whale has broken surface, together with such a view of the body as may be gained while still beneath the water, suggests that the whale has, at first, a straightened back (Fig. 5*a*). Towards the end of the action, on the other hand, the caudal peduncle is strongly curved and the body is presumably arched (Fig. 5*g*).

The whale breaks surface with a high forward velocity which then decelerates until eventually the exposed portions at the hind-end have very little forward motion, but instead a marked vertical component.

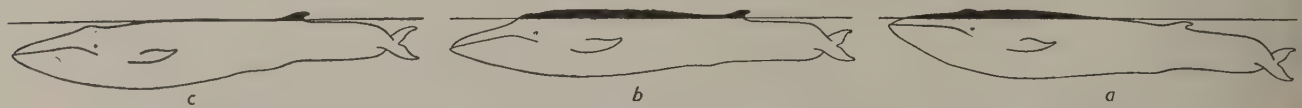

Fig. 4. Diagrams illustrating the posture of Fin whales engaged in breaking surface and submerging leisurely.

The shape of the animal appears to the writer to be particularly suited to this act of submergence. An outstanding characteristic of the Fin whale's back anterior to the dorsal fin is its breadth, and the head especially is flattened. This is a fact that has frequently been noted, though its function appears to have been overlooked (Scammon, 1874, p. 34; Millais, 1906, p. 243). The dorsal fin itself and the caudal peduncle behind it, as remarked by Collett (1886, p. 247), Olsen (1913, p. 1076), Gray (1936, p. 199) and others, is sharply acuminate. Gray has pointed out the value of such a peduncle to the normal swimming actions of fast-swimming forms, but among rorquals it seems to have a further advantage. It will be seen that when the whale approaches the surface its action conforms most closely to the normal swimming—the body is straight and it travels forwards with high velocity—but that when leaving the surface, the body loses forward movement, arches and takes on vertical movement in a dorsoventral plane for which, in section, the fin and peduncle are well shaped.

In considering the implications of these movements, the following observations are also of assistance.

The oily looking patch left on the surface where the whale submerges, indicates that the last beat of the flukes is in an upward direction (Fig. 5*g–j*). Such action would of course be necessary to drive the whale downwards. But it follows that the penultimate beat is in a downward direction (Fig. 5*e–f*). A downward beat of the tail flukes would tend to lift the posterior part of the trunk unless the latter were able to carry out some other compensatory movement. In this connexion, the observations shown in Fig. 5*d–g* are probably significant since they show that while the body is arching, the back rises out of the water. Compare with this also the actions of the whales noted on 31 January and 7 February which dived suddenly while still beneath the surface with the hind-end of the body as they did so; one thrusting the dorsal fin and the other, both fin and peduncle out of the water (p. 124).

It would appear that the movement of the whale after it has blown, is to dip the head and the tail (Fig. 5*d*, *e*). The action of the muscles near the neck and shoulder have been noted, and at this time the whale is still travelling forwards. The arching of the body in the region of the dorsal fin shows that

the tail is also being flexed, and its rising out of the water, as noted in the figures, may be regarded as a consequence. The resulting posture probably resembles that shown in Fig. 5*g*, and the whale would appear to have gained a position of mechanical advantage: almost as much is hinted by Racovitza (1903, p. 36). In this position, the flukes are sufficiently buried to have purchase for the final dive, while the flattened head and the broad shoulders reaching downwards afford a bearing against which force can be transmitted.

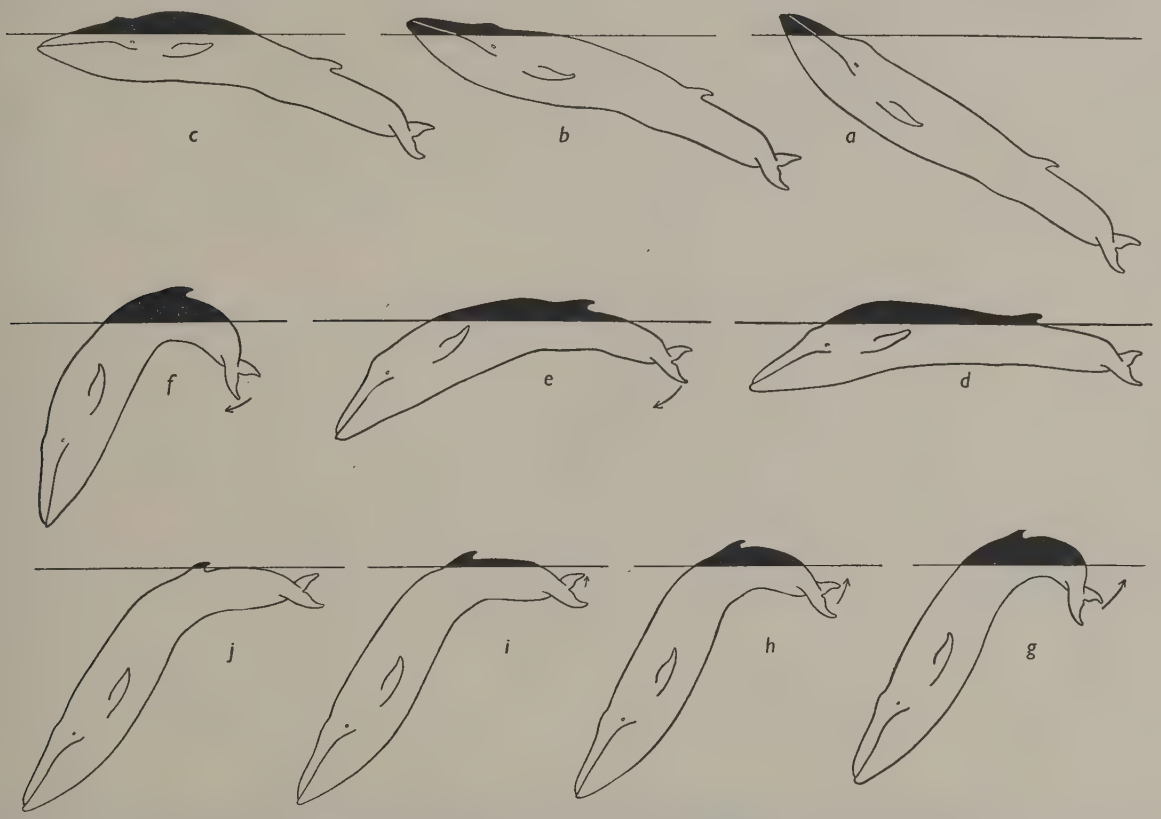

Fig. 5. Diagrams illustrating the posture of Fin whales in ten stages while breaking surface and submerging at medium speed. The arrows in *e–i* indicate the supposed direction of the beat of the tail flukes.

The head, dorsal fin and caudal peduncle

The head in rorquals may thus function as a vane and may perhaps be compared to the outstretched hands of a diver or to the elevators of a submarine. In the vertical plane its effects would thus appear analogous with those shown by Gray (1933, pp. 115–24) to result from lateral turning of the head in fish.

Authors have usually found difficulty in ascribing an appropriate function to the Balaenopterid dorsal fin, and Howell (1930, p. 59), while suggesting its possible use as an equilibrator, also points out the difficulty of accepting this conclusion about an animal swimming by a vertical motion of the tail.

The fact observed above that the fin is usually the last part of the body to sink beneath the surface and that it makes no splash, suggests strongly that it is streamlined for the purpose and that it facilitates submergence. Closer examination shows that the leading edge of the fin is normally set at an angle of about 150° to the back anterior to it, but the angle is greatly increased when the back is arched so that the edge of the fin tends to come into line with the curve of the back. The broad lines of the

back in the bent position thus taper until the tip—not of the tail—but of the fin is reached, and as they submerge together, the whole sinks obliquely forwards with remarkably little disturbance to the water.

The caudal peduncle should be considered together with the dorsal fin because it seems to share the same function and has similarity of shape. Its structure has been frequently misrepresented (Scammon, 1874, p. 37 and plate 11, fig. 2; True, 1904, plate 48, fig. 1; Millais, 1906, plate 59, figs. 2, 3; Lillie, 1915, plate VII, fig. 1; Allen, 1916, plate 10, etc.).

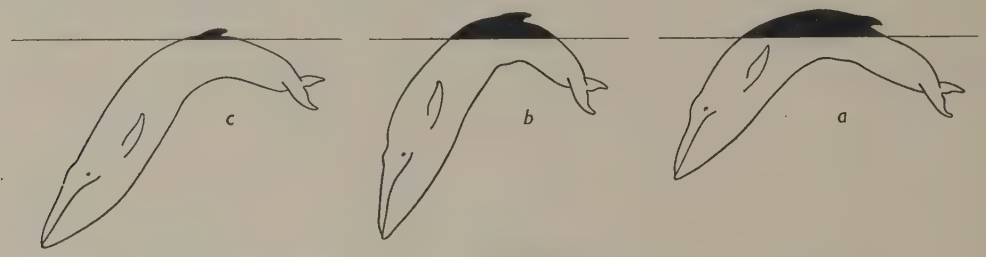

Fig. 6. Diagrams illustrating the posture of Fin whales swimming at high speed.

The point in need of particular emphasis, is the insertion of the flukes on the peduncle. The majority of authors have shown the plane of the flukes to lie more or less midway between the dorsal and ventral contours of the peduncle, whereas in fact it is very distinctly nearer the ventral edge. In Fig. 7*a*, which is based on photographs published by True (1904, plate 11, fig. 4 and plate 14, figs. 1, 2), two-thirds of the peduncle are shown dorsal to the plane of the flukes and in southern Blue and Fin whales it is approximately the same (Plate XXXIII, fig. 6; Fig. 7*b*). Collett (1886, plate XXV, fig. 1) and Olsen (1913, plate CXI, fig. 7) have respectively shown the same thing for the Sei whale and Bryde's whale.

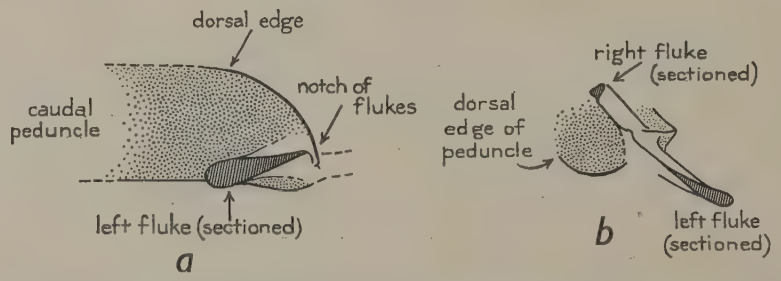

Fig. 7. Diagrams of the caudal peduncle. *a*, viewed from the left side (*Balaenoptera musculus*, from True, 1904). *b*, viewed from behind and from the right side, as in Plate XXXIII, fig. 6 (*B. physalus*).

When whales dive at unusually steep angles they submerge the fin before the peduncle and the streamline form of the latter in transverse section is then seen to best advantage. By its great depth—4 ft. in a 65 ft. whale (Howell, 1930, p. 204)—the flukes are kept well beneath the surface as long as possible.

In considering the effects of the flattened head and its mobility, the streamlined dorsal fin and the caudal peduncle, it would be interesting to know more about the habits of other whales. The Right whale is also a plankton feeder and visits the surface to breathe but is said to be slow in its movements. In this whale the maxillae are laterally narrow and dorsoventrally curved; mobility of the head is reduced by extensive fusion of the cervical vertebrae and it has no dorsal fin. Killer whales and dolphins which feed upon active prey have very much larger dorsal fins placed farther forward. The

possible advantage of this to an organism in need of turning sharply to right and left is suggested by the results obtained by Harris (1936) on the dorsal fins of fish, and it seems probable that the fins of rorquals are in no way analogous to the fins of these other cetaceans.

As compared to the ease with which rorquals are able to turn sharply upwards or downwards, their movement from side to side appears to be restricted. This is suggested both by the structural arrangement of the fins, flukes and flippers, and also by the behaviour of Fin whales when feeding. Their habit of turning on to their sides when moving about among small patches of food has often been recorded (Millais, 1906, p. 255), and Andrews (1909, plate XL, fig. 1) has photographed a whale in this position. This seems most probably to be a turning movement. The very localized and irregular distribution of the krill must demand a twisting motion which is probably beyond these whales in their normal swimming position. The flattened head and laterally extended flukes, while they are evidently well adapted for the purposes of turning upwards or downwards to and from the surface, seem incapable of giving an equally sharp turn to right or left: like an aeroplane it has to bank.

III. COMPARISON WITH EARLIER ACCOUNTS

True (1903) and Allen (1904) give brief descriptions of Finbacks off Newfoundland which agree well with the type of movement described on pp. 116, 117. True, however, reports having seen little or nothing of the back behind the dorsal fin, although the whales are described as having come up to the surface obliquely and as exhibiting strong curvature (p. 92). On some points, however, True's photographs differ from the text. In his plate XXV, fig. 1, a relatively short length of back shows above water as its curvature and the position of the head clearly indicate. The fin is still well submerged; yet True states that 'The whole upper surface of the body from about the middle of the head to the dorsal fin is above water...'. The text suggests that in fig. 2 the dorsal fin is hidden by a wave, but the position of the whale shows clearly that the fin itself is outside the picture and is probably still below water.

Both True and Allen note the lowering of the head and the arching back, but neither draws attention to the fact that the back rises out of the water, nor that the wheeling motion slows down. Millais (1906, p. 268), however, states 'The Finback simply lifts itself a little higher and goes down smoothly and silently and goes down at an oblique angle', and Andrews (1909, p. 216) makes a similar remark.

Racovitza (1903) distinguishes between two types of action at the surface, the one concerned with the longer and deeper dive which he terms 'La Sonde' and the other with 'Les plongements intermédiaires'. According to Racovitza, inspiration and expiration are deeper before and after sounding than before the intermediate dive, but comparative data are not given. Again, the intermediate dives last a few minutes, whereas sounding seldom lasts less than a quarter of an hour, but more precise data are not given. The whales are also said to dive more shallowly intermediately than when sounding, though how the depth of the whale was judged during the minutes it was out of sight is not made clear. And lastly, the curvature of the back is held to be greater before sounding than before the intermediate dive. Racovitza ascribes a regularity to these movements which the present writer finds impossible to accept; they will be considered in further detail.

His first point (p. 6) that 'L'expiration se produit exactement au moment où le sommet de la tête,...arrive à la surface' does not reckon with the habit Fin whales sometimes have of blowing off air while the blowhole is still submerged (see p. 117), which appears also to have been noted by Howell (1930, p. 91). And his claim that 'C'est la bosse de l'évent qui signale l'animal' can be accepted only for those whales which approach the surface in a more or less horizontal position. Such whales appear to have been observed by Allen (1904, p. 615).

Racovitza has allowed 5–6 sec. for the duration of the blowing, which is greatly in excess of our

estimate. According to direct observations made during the course of the present work, little more than 1 sec. elapsed from the first appearance of the head above water to the submergence of the blow-hole. This is astonishingly short and is rather shorter than an estimate of the time made by indirect methods, according to which the blowing might perhaps take 3 sec., but even this is half the time allowed by Racovitza.

We are agreed with the view that the time taken over inspiration is shorter than the time taken over expiration which immediately precedes it. Racovitza, however, maintains (p. 12) that 'La bosse de l'évent est toujours la seule partie qui apparaît à ce moment sur l'eau', whereas numerous photographs of living whales have shown other parts of the head and neck also above water. On p. 13 he notices the neck bend, but for the intermediate dives he states that 'chez les Balénoptères la dorsale ne se montre pas'. In the present series of observations, the dorsal fin showed above water after almost every act of blowing seen (see p. 127).

Whether it is possible to infer from the attitude of a whale whether it is making an intermediate dive or whether it is sounding, may be questioned, as indeed may so many of Racovitza's assertions. Andrews (1909), whose ideas are evidently modelled to a considerable extent upon Racovitza and Millais, touches upon the subject but gives little that can be looked upon as corroborative evidence. The posture of a whale diving at a steep angle is admittedly different from that of a whale swimming horizontally, but whales have frequently been seen by the writer to dive at a steep angle during intermediate dives.

The view expressed by Andrews (1909) and Allen (1916) that the 'slick' left by the whales is due to the counter-currents produced by the displaced water as the whale comes to the surface and withdraws; or that it is 'incontestablement une couche de graisse extrèmement mince, qui s'étent à la surface de l'eau et qui lui donne cet aspect bien connu du miroir' (Racovitza, 1903, p. 15); or yet again, the theories elaborated earlier leave out of account the fact that the patches often appear in series when the whale does not break surface. They seem far more likely therefore to represent a gush of water propelled upwards by the tail flukes.

Respiratory rhythm

Racovitza's estimate of the time taken over an intermediate dive 'plus ou moins longtemps, mais sans jamais dépasser un petit nombre de minutes' (p. 13), like his estimate of sounding 'rarement inférieure à un quart d'heure' (p. 14) are far longer than our own.

Owing to their limited number, our observations by no means exclude the probability that whales can and do remain below for very much longer periods than we have been able to show. The estimates of 15 min. made by Millais (loc. cit. p. 268) and of 23 min. by Andrews (1909, p. 225) are by no means unreasonable and are to be expected from our data. But periods of over a quarter of an hour are certain to be exceptional as compared to the frequency of sounding for shorter periods.

In this our results confirm the observations of Allen (1904, p. 615) 'They rose to spout about once in every 12 to 15 seconds with great regularity for perhaps twelve times, after which they dove for a much longer stay of several minutes. The precise length of the longer periods was not accurately determined, but could hardly have been more than five or ten minutes.'

The mean of seven instances of such rhythm given in Table 1 shows the schools to have been blowing at 16 sec. intervals seven to eight times and then to have been sounding for about 4 min. Individual whales were blowing less often, however; the figures gave an average of four to five times at intervals of 26–27 sec. between each sounding. When feeding at the surface, or in flight, whales did not show this rhythm and sounded less, so that the respiratory rhythm reflected to some extent their occupation. Andrews (1909, p. 224) also has observed 'that Finbacks, when feeding, often rise to respire with

considerable regularity, but in general the time the animals will remain submerged is most uncertain'. Whether this has any connexion with the depth of the food is not known and it was unfortunately impracticable on the *Skua* to tow nets with the object of locating it.

Feeding

Dudley (1725, p. 262) has made a suggestion that has often been copied by later writers (Buchet, 1895; Racovitza, 1903) that Fin whales 'with a short turn, cause an Eddy or Whirlpool by the Force of which, the small Fish are brought together into a Cluster; so that the whale with open Mouth, will take in some Hundreds of them at a Time'. The practice has not been seen by the writer.

The swarming habit of *Euphausia superba*, the staple of whale food around South Georgia, is a characteristic to which Hardy & Gunther (1935) have already drawn attention. Patches of krill at the surface of the sea, similar to, but more pronounced than, those noted on p. 124 have been observed by the writer in areas marked by a conspicuous absence of whales, which need not be instrumental, therefore, in bringing the swarms about. The belief would seem to have arisen as a fisherman's explanation of the swarming and its frequent association with 'boltering' whales (see p. 131).

Millais (1906, p. 255), who also passes the story on, states 'After one or two subsidiary circles to drive their prey together, they give a sudden start forward, at the same time turning on their side and erecting the pectoral fin'. Erection of the flipper has been noted on p. 124 and is also figured by Andrews (1909, plate XL, fig. 1). It would seem likely to help the whale both to turn on to its side and to lessen the radius of its track.

Gambols

Compared to the Humpback, Fin whales are described as seldom indulging in gambols or other antics, though movements that are not habitual are sometimes noted. Scammon (1874, p. 35) writes: 'It frequently gambols about vessels at sea, in mid-ocean as well as close in with the coast, darting under them, or shooting swiftly through the water on either side; at one moment upon the surface, belching forth its quick ringing spout, and the next instant submerging itself beneath the waves, as if enjoying a spirited race with the ship dashing along under a press of sail.' But this author is alone in noting that the Fin whale sometimes heaves its flukes out. The present writer is able to confirm an observation made by Allen (1916, p. 194) that one or other but never both flukes leave the surface.

Millais (1906, p. 218) has referred to an observation that when a party of Killers were attacking a Common Rorqual, the main herd of whales about a mile to windward, began lashing about on the surface to give the alarm, and were seen then to make off at great speed in all directions. Later (p. 268) he states that the flukes never leave the surface, so that the lashing might have been with the head or flipper.

Allen (1916, p. 194) states that 'The Finback whale seems but rarely to leap out of water'. One is reported to have done so after it had sustained injury upon some rocks, and he quotes another instance of breeching reported by Prof. W. Kukenthal.

Breeding habits

The available descriptions of courting and of other breeding habits admit of the possibility of a variety of methods by which union of bull and cow or cow and calf might be effected, but all writers, so far as is known, have omitted to stress the principles underlying the manner of approach of the partners to one another (Dudley, 1725, p. 260; Haldane, 1906, p. 133; Southwell 1906, p. 195; and others).

As bodies floating in the water and unpossessed of prehensile limbs, they lack the purchase on terra firma by means of which animals on dry land are able to make physical contact. This disability would

seem most easily overcome when whales have steerage way, and in fact, pilots know well the nice adjustments of which craft are capable provided they have sufficient way on. Animals so well adapted to the water as whales, which swim for almost every breath, might reasonably be expected to swim for their other essential functions; and the suggestion by Anderson (1746), Pontopiddan (1752), Brown (1868) and Millais (in respect of the dolphin, 1906, p. 220) that cetacea adopt a vertical position, or by Lillie (1910, p. 791) that they make several dashes at one another, seem unlikely both on account of lack of good evidence and on account of the principles noted above.

Whales with calves were observed on various dates but never seen to suckle. Whether the calf takes the teat between the extremity of the jaws (Scammon, 1874, p. 45) or whether in the corner of the mouth (Haldane, 1906, p. 133) remains an open question, and the way in which the apparently rigid lips are able to take milk to the exclusion of salt water is also an undecided question.

Whales with calves were usually timid. They were noted on 12 and 23 December, 7, 12, 30 January and 7 February. On 22 January a whale with a very young calf showed an unusual unconcern for the ship and swam close to her; this was an occasion when the whales were judged to be feeding (p. 124). The whale of 7 February was attended by two calves and was brought within range. The mother (?) and one calf were marked (nos. 7348 and 7370 (cow) and 7369 (calf)), but though the family were chased for an hour and a half the second calf got away unmarked. Their rates of blowing for a period of 8 min. are noted in Table 4.

Intercommunication between whales

The behaviour of the school leaves no doubt that intercommunication is remarkably efficient, but as to the means nothing is definitely known. The precision with which four and five whales will blow together, and the way in which schools half a mile or so apart readily join up, or when scattered over a very much wider area, coalesce, are instances that may be witnessed every day. The senses of sight, smell, taste and hearing may each have their part.

Whales in close formation are doubtless able to see each other, for in deep water and at night they probably leave a trail of luminescence behind them, induced in the planktonic organisms. Such luminescence is known to be produced by dolphins but as an effective recognition signal it can hold for only short distances.

Little is known about the whale's olfactory sense. As regards airborne smell, it is of interest that a whale's breath may be detected at a distance of at least 200 yards to windward, but this may be excluded for purposes of communication because scent is not usually detected on the surface of water. Waterborne smell is a possibility that might affect the whale through some such organ as Jacobsen's organ, or through taste.

The problem of locating food has application here, for if a sense of smell or the taste buds of the tongue subserve this purpose, they may also enable the whales to trace one another. On the other hand, the presence of food may be detected physically by means of the bristles of the head which have been shown to be highly innervated.

The hearing of whales is remarkably sensitive. The report of a small charge of gunpowder in open ocean against wind and at a distance of several yards, has put whales beneath water to flight (see also p. 122). Norwegian whalers believe that whales hear the shout of a man in the crow's nest. A sensitive ear or equivalent sense in the bones of the head, implies use and raises the question of what sounds may be produced by whales.

Their blowing on a calm day can be heard half a mile away, but we do not know whether the noise is transmitted to water. On two occasions the low vibrant quality of the note was accompanied by a higher. An observer on board ship can never be sure that an unusual note coinciding with a whale's

appearance has not had its origin on board. Apart from these, and in spite of the close attention that has been paid to the subject during this commission, no other noises have been identified with the whales.

Asymmetrical pigmentation of Fin whales

An account of the pigment distribution in Fin whales has been given by Mackintosh and Wheeler (1929), and attention is directed to the asymmetrical arrangement of pigment on the jaws (p. 354). The report also makes an interesting speculation on the possibility that Fin whales might swim slightly on their right side while under the water.

The suggestion is based, presumably, on the analogy of Thayer's ducks, according to which the shadowed and the highly lit aspects of an animal are differently pigmented; or alternatively there is the theory that the more exposed portions of the whale may be pigmented as a protection against the action of the sun's rays. In either case a regular turning on to the right side might reasonably be expected.

Of the many whales watched, a vast majority broke surface and sounded on an even keel. Moreover, of the whales which turned on to their sides when 'boltering' or when raising a single fluke above the surface, some were on their right side, others on their left. As far as they go, the observations give no evidence of habitual twisting in the water and the asymmetrical distribution of pigment remains a problem.

SUMMARY AND CONCLUSIONS

1. The habits, swimming manœuvres, bodily movements, respiratory rhythm and reactions of fin whales have been noted during a programme of whale marking operations near South Georgia. The observations were made between Dec. 10th and Feb. 9th, 1936–7. At this season the whales are known to be feeding.

2. An observed reaction to the presence of the ship has been an alteration in the respiratory rhythm, but other changes of behaviour are likely. Difficulties of observing whales at a distance are pointed out and the view obtainable from the decks of a catcher might give rise to a wholly erroneous picture of the ways of the unmolested animal. With these reservations the following deductions have been made.

3. The way the whale breaks surface to breathe and submerges again is analysed into its component movements. In the process of submergence the body may travel forwards with the body extended, or downwards with the body doubled. The latter was the most usual and the structure of head, dorsal fin, peduncle and flukes are shown to be particularly adapted for this action. Breathing requirements impose a need to overcome mechanical difficulties not met with by fish. Quick visits to the surface would seem to involve certain mechanical difficulties which these adaptations are designed to overcome: and this specialization for dorsi-ventral turning has resulted in the peculiar habit of feeding on the side.

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APPENDIX

Table 3. *List of blowing intervals timed by stop-watch*

Series no.	Serial no. of observation	Date	Corrected interval	No. of blows observed	Notes
			min. sec.		
1	1	12. xii. 36	25		Two whales
	2		27		
	3		27		
	4		25		
	5		52		
	6		32	1	
	7		29	1	
	8		2 27	1	
	9		48	½	
	10		2 02		
	11		51		
	12		5 02	1	
	13		26	1	
	14		19	1	
	15		18	1	
	16		?	1	
	17		20	1	
	18		27	1	
	19		35	1	
	20		?		
	21		22	1	
	22		4 29		
	23		40	1	
	24		22	1	
	25		17		
	26		—		
	27		28	1	
	28		28	1	
	29		16	1	
	30		23	1	
	31		10	1	
	32		44	1	
	33		17	1	
	34		13	1	
	35		30	1	
2	36	14. xii. 36	55	2	
	37		5 32	1	
	38		17	2	
	39		19	1	
	40		6 02		
	41		6 02		Abandoned chase of disappearing whale
3	42	14. xii. 36	39	1	
	43		2 28	1	
	44		38	1	
	45		30	1	
	46		27	2	
	47		17	1	
	48		13	2	
	49		6? 23	1	
	50		33	2	
	51		25	1	
	52		11	1	
	53		52		
	54		34		
	55		3 27		
	56		19		
	57		2 15	1	

Table 3 (*cont.*)

Series no.	Serial no. of observation	Date	Corrected interval	No. of blows observed	Notes
			min. sec.		
	58		22		
	59		18	1	
	60		25	1	
	61		22	1	
	62		09		
	63		? 22	2	
4	65[1]	14. xii. 36	35	1	>1 whale
	66		22	1	
	67		1 19	1	
	68		20	1	
	69		1 27	1	
	70		17	2	
	71		17		
	72		13		
	73		7		
	74		19		
	75		7		
	76		21	2	
	77		1 38	1	Remainder disappeared after marking
	78	14. xii. 36	7		
	79		22		? joined group ½ mile off
5	80	15. xii. 36	12	1	
	81		14	1	
	82		12	2	
	83		16	1	
	84		12	2	
				1	
6	85	18. xii. 36	15	1	Two whales approached slowly and fled in calm weather, light breeze, sun and mist
	86		27		
	87		3 47		
7	95	22. xii. 36	7 30		Loitering ¼ mile distant
	96		?		
	97		22		
	98		16		
	99		19		
	100		12	2	
	101		19		
	102		12		
	103		3 18		
	104		24		
8	105		12		
	106		50		
	107		4 27		
	108		28		
	109		14		
	110		8		
	111		9		
	112		14		
	113		10		
	114		14		
	115		19		
	116		2 14		
	117		52		
	118		54		
	119		22		
	120		22	2	
	121		21	2	
	122		13		
	123		9 2		

[1] No. 64 omitted in M.S.—*Ed.*

Table 3 (*cont.*)

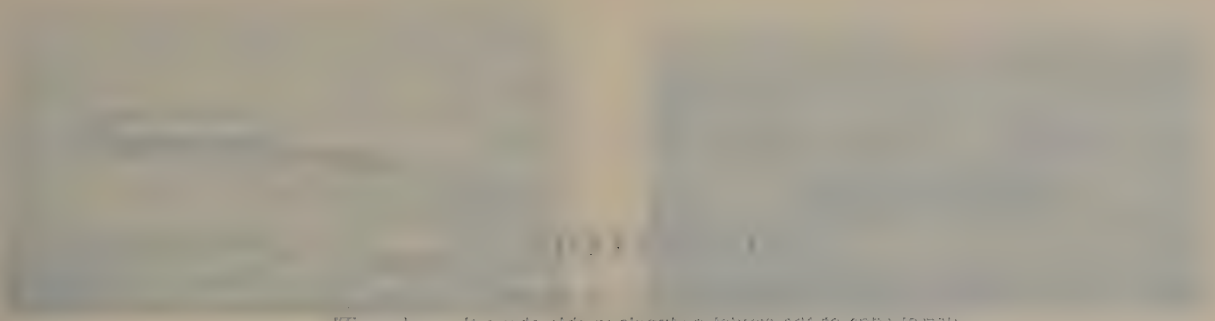
Series no.	Serial no. of observation	Date	Corrected interval	No. of blows observed	Notes
			min. sec.		
	124		57		
10	185	27. xii. 36	15	3	3 Fin, 1 mile
	186		15	3	
	187		17	1	
	188		17	1	
	189		2 52	1	
	190		25	3	
	191		27	3	
	192		11	1	
	193		13	2	
	194		8	1	
	195		9	2	
	196		11	1	
	197		13	2 (or 3)	
	198		27	2	
	199		?		? 1 interim blow
	200		1 7	1	
	201		19	3 or 2	
	202		26	3	
	203		14	2	
	204		15	1	
	205		10	2 ?3	
	206		19	1	
	207		26	2	
	208		34	1	
	209		17	3	
	210		19	3	
	211		15	1	
	212		11	3	
	213		17	2	
	214		21	3	$\frac{1}{4}$–$\frac{1}{2}$ mile
	215		22	2	
	216		26	2	
	217		34	3	
	218		9	1	
	219		21	1	
	220		12	1	
	221		12	2	
	222		18	2	
	223		18	2	
	224		11	1	
	225		12	2	
	226		14	2	
	227		19	2	
	228		9	1	
	229		7	1	
	230		11	2	
	231		15	1	
11	232		13		4 min. after last record: 3 whales swimming parallel to ship and left on starboard quarter
	233		9		
	234		19	3	
	235		25	3	
	236		8	1	
	237		8	1	
	238		13	2	
	239		17	1	$\frac{3}{4}$ mile
	240		22	?1	
	241		25	3	
	242		9	1	
	243		17	1	

Table 3 (*cont.*)

Series no.	Serial no. of observation	Date	Corrected interval	No. of blows observed	Notes
			min. sec.		
	244		9	1	
	245		14	2	
	246		19	2	
	247		9	1	
	248		6	2	
	249		9	?3	
	250		12	2	1 mile
11	251	27. xii. 36	12	2	
	252		9	1	
	253		7	1	
	254		17	1	
	255		10	2	
	256		24	1	
	257		9	2	
	258		54	1	
	259		10	1	
	260		12	2	
	261		18	1	
12	262		7		2 miles
	263		35		
	264		37		
	265		30		
	266		1 37		
	267		3 17		
	268		9		
	269		11		
	270		11		4 whales
13	271		6 6	1	?2 miles
	272		27	2	?½ mile
	273		17	1	
	274		17	2	
	275		12	1	
	276		8	1	
	277		11	3	
	278		11	1	
	279		13	1	
	280		9	2	
	281		55	1	¼ mile
	282		10	1	
	283		14	1	
	284		39	1	
14	285		9	1	Ship receding
	286		54	1	
	287		11	2	
	288		9	1	
	289		22	1	
	290		8	1	
	291		7	2	
	292		26	1	
	293		7	1	
	294		14		
	295		2 50		
	296		28		
	297		23		
	298		22		
	299		26		
	300		18		
	301		34		?1 min. 34 sec.
	302		13		?2 miles off

Table 4. *Timing observations of an adult and two calves*

Series no.	Serial no. of observation	Date	Corrected interval	Observed appearances		Supposed appearances	
				Adult	Calves (nos.)	Calf	Calf
			min. sec.	min. sec.	min. sec.	min. sec.	min. sec.
15	303	7. ii. 37	00				
	304		29		29 (1)		
	305		10	39			
	306		18		28 (1)	?	57
	307		19	37			
	308		19		38 (1)	1 6	1 6
	309		28	?47	?28 (1)		
	310		23	23			
	311		28	28			
	312		18	18	1 9 (1)	1 37	
	313		24	24	24 (2)	24	1 33
	314		23	23	23 (1)	23	
	315		12		12 (1)		35
	316		9		9 (1)	21	
	317		15		15 (1)		24
	318		1 42	2 18	1 42 (2)	1 57	1 42
	319		18	18			
	320		9		27 (1)	27	
	321		14	23			
	322		1 42		1 56 (2)	1 56	2 23



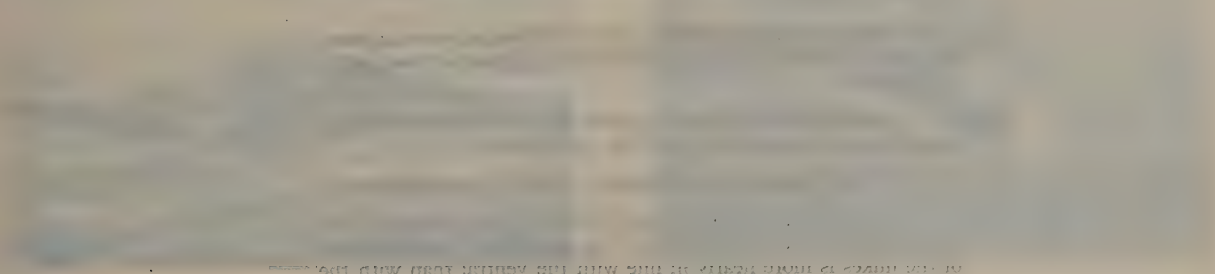


PLATE XXXIII

Fig. 1. Fin whale blowing leisurely, with blowhole, dorsal fin, and dorsal edge of the caudal peduncle visible above the surface. The appearance of the peduncle suggests that the body is exceptionally horizontal. (See Fig. 1*b* in the text.)

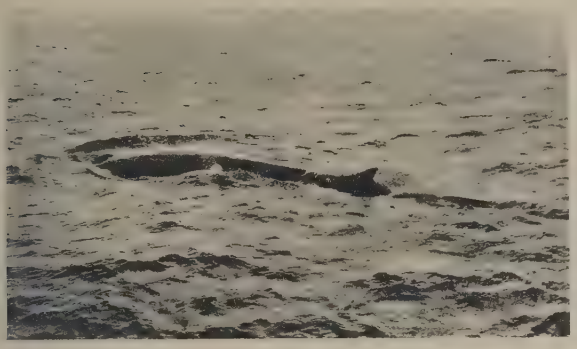
Fig. 2. Fin whale blowing fairly leisurely, with blowhole and dorsal fin both visible. The 'spout' is just visible above the back, and the head has moved forward (to the right) during inspiration. (See Fig. 1*b* in the text.)

Fig. 3. Fin whale blowing at medium speed. The whale is moving away from the observer, and the open blowhole can be seen. (See Fig. 1*f* in the text.)

Fig. 4. Fin whale blowing at medium speed. The back is flexed and the blowhole now submerged. (See Fig. 1*g* in the text.)

Fig. 5. Fin whale blowing at high speed. (See Fig. 1*n* in the text.)

Fig. 6. View of Fin whale from the rear, to show height of dorsal edge of caudal peduncle. The whale is lying on its left side. The plane of the flukes is more nearly in line with the ventral than with the dorsal edge of the peduncle. The outer parts of the flukes have been cut off. (See Fig. 7*b* in the text.)



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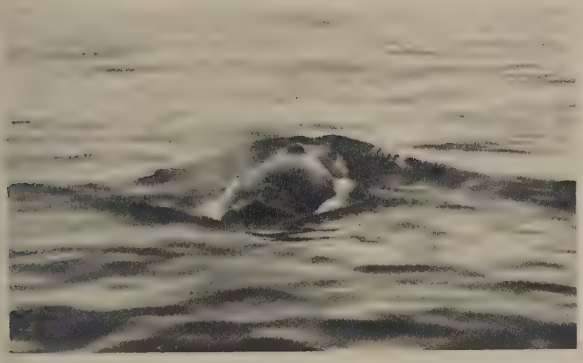

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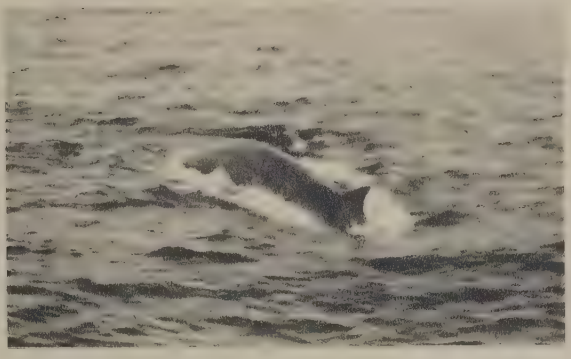

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FIN WHALES